Impact of ENSO-related Weather and Climate Conditions on Wheat Yield in Alabama

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Interannual climate variability causes high uncertainty on farmers' management decisions as weather and climate have a direct impact on crop production. Wheat production in the southeastern U. S. occurs during the winter and spring months when climate is highly influenced by the El Niño Southern Oscillation (ENSO). Therefore, a better understanding of the impacts that ENSO-related weather and climate conditions have on wheat growth and final yield are key to reduce yield losses.

Objective: Establish the relation between ENSO-related weather and climate conditions and Wheat Yield in Alabama (AL).

Materials and Methods:

1. Historic wheat yield records from Alabama Official Variety Trials (1982-2010) collected at eight research stations (Fig. 1) were used to identify yield differences by ENSO phase and test the interaction location × ENSO phase. Annual average wheat yield data was classified according to ENSO phase using the JMA index. Analysis of variance (ANOVA) was used to test wheat yield differences between ENSO Phases and interactions.

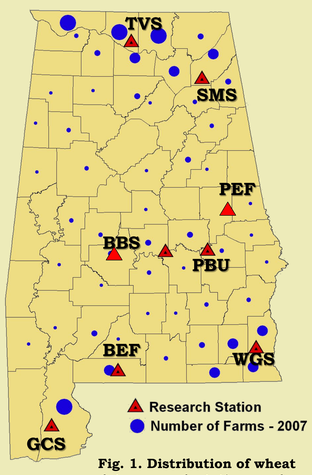
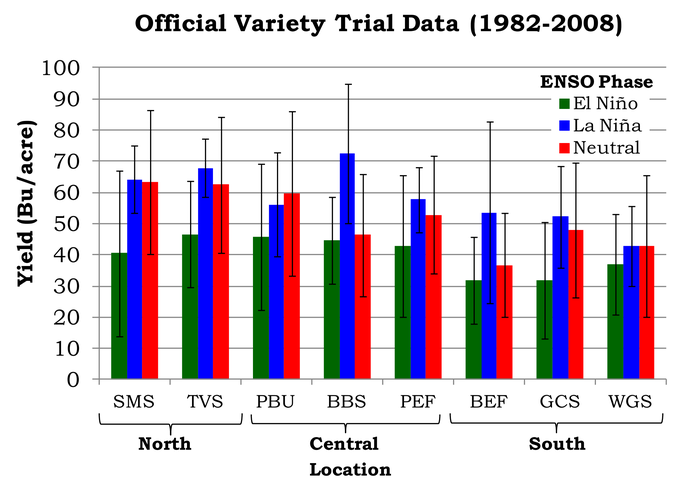


Fig. 1. Distribution of wheat data research stations and number of wheat farms in AL.

2. Historic weather data (1982-2010) collected at the eight research stations was used to study the differences between ENSO phases respect to Precipitation, and Maximum and Minimum Temperature. Those differences will be used to explain ENSO-related wheat yield differences.
Canonical Discriminant Analysis was used to identify the weather and climate conditions, based on the Precipitation, and Maximum and Minimum Temperature variables, characterizing and differentiating each ENSO phase. This analysis will allow identification of ENSO climatic conditions favoring or reducing wheat yield at various locations in Alabama.

Wheat Yield Differences by ENSO phase



Phase	Average yield	StdErr	Simulation adjusted *P*-value vs.	
			Neutral	El Niño
	---- bu acre $^{-1}$ ----			
La Niña	59	3.6	0.0958	0.0002
Neutral	50	1.7		0.0010
El Niño	39	2.6		

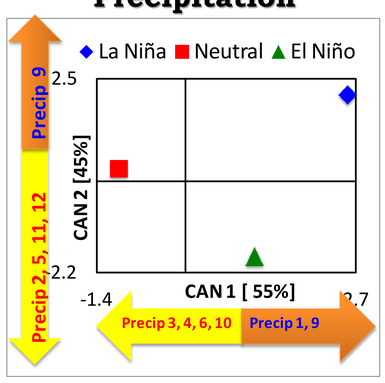
Wheat yield differences were significant between ENSO phases. The interaction ENSO phase × location was not significant. The highest wheat yields were observed for La Niña years contrasting with El Niño with the lowest yield.

For all the eight study locations, wheat yield was higher during La Niña and Neutral years. The higher differences between El Niño (low yield) and the other two phases were observed in North AL (SMS, TVS) and South AL (GCS). The smallest differences between ENSO phases was observed in Southeast AL. (WGS). The smallest yield fluctuations were observed during La Niña years with special attention in North AL.

Weather variables driving differences among ENSO Phases

Canonical Discriminant Analysis of Historic Weather Data

Precipitation



Precipitation	Corr. with **CAN 1**	Left to right order along **CAN 1**		
		Neutral	El Niño	La Niña
		---------- inches ----------		
Jan.	0.98	0.17	0.19	0.21
Mar.	-0.94	0.20	0.15	0.16

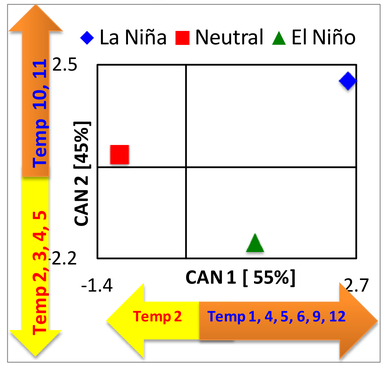
Along **CAN 1**, precipitation in January increases from Neutral, Niño to Niña. In contrast, it decreases from Neutral, Niño to Niña in the month of March.

Precipitation	Corr. with **CAN 2**	Bottom to top order along **CAN 2**		
		El Niño	Neutral	La Niña
		---------- inches ----------		
Sep.	0.70	0.14	0.14	0.26
May	-0.99	0.17	0.13	0.07

Along **CAN 2**, precipitation in September increases for La Niña and it decreases in May compared to the Neutral and Niño years.

CAN 1 reflects a gradient from Neutral, to Niño and then Niña. Niña years differed from the others in that Precipitation was lower in the months of March- April (grain filling), June (Harvest), and October. During Niña years, precipitation increments can be observed in September and January. **CAN 2** reflects precipitation reduction in November-December (Tillering), February, and May (Grain filling) associated with La Niña years.

Temperature



Temperature	Corr. with **CAN 1**	Left to right order along **CAN 1**		
		Neutral	El Niño	La Niña
		---------- °F ----------		
Tmin Jan.	0.99	33.6	35.3	36.4
Tmax Feb.	-1.00	61.0	60.4	60.3

Along **CAN 1**, Temp. minimum in January increases from Neutral, Niño to Niña. In contrast, Temp. maximum decreases from Neutral, Niño to Niña in the month of February.

Temperature	Corr. with **CAN 2**	Bottom to top order along **CAN 2**		
		El Niño	Neutral	La Niña
		---------- °F ----------		
Tmin Nov.	0.99	42.5	43.1	43.8
Tmin Mar.	-0.99	45.0	43.8	42.2

Along **CAN 2**, Temp. in November increases for La Niña and it decreases in Mar. compared to Neutral and Niño.

For **CAN 1,** Niña years differed from the others in that Temperature was higher most of the year (January, April, May, September, December) with low temperatures in February. **CAN 2** shows that high temperatures in October and November distinguish La Niña years from the other phases. In addition, low temperatures from February to May separate La Niña years from El Niña and Neutral years.

Conclusions: Wheat-growing season weather and climate conditions are affected by ENSO resulting on yield differences. Lower wheat yields during El Niño years respect to La Niña years suggest either changes in management practices, use of wheat as cover crop not a cash crop, and/or different market strategies. The identification of precipitation and temperature differences between ENSO phases facilitate the establishment of adaptation strategies and understanding of wheat phenological changes associated with yield variability.